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Supply Chains Resilience within Machine-made Rug Producers in Iran

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Abstract—In recent decades, the role of supply chains in sustaining businesses and establishing their superiority in the market has been under focus. The realization of the goals and strategies of a business enterprise is largely dependent on the cooperation of the chain, including suppliers, distributors, retailers, etc. Supply chains can potentially be disrupted by both internal and external factors. In this paper, resilience strategies have been identified and analyzed in three levels: sourcing, producing, and distributing by considering economic depression as a current risk factor for the machine-made rugs industry. In this study, semi-structured interviews for data gathering and thematic analysis for data analysis are applied. Supply chain data has been gathered from seven rug factories before and after the economic depression through semi-structured interviews. The identified strategies were derived from literature review and validated by collecting data from a group of eighteen industry and university experts, and the results were analyzed using statistical tests. Finally, the outsourcing of new products and products in the new market, the development and completion of the product portfolio, the flexibility in the composition and volume of products, the expansion of the market to price-sensitive, direct sales, and disintermediation have been determined as strategies affecting supply chain resilience of machine-made rugs' industry during an economic depression.

Keywords—Distribution, Economic Depression, Machine-Made Rug, Outsourcing, Production, Sourcing, Supply Chain, Supply Chain Resilience.

I. INTRODUCTION

Today's world is faced with increasing dynamism and global chaos and along with that, supply chains have expanded and become more complex. With the rapid growth of technology and scarcity of resources, supply chains have evolved quickly and played an important role in the industries. Supply chains are regularly facing natural and human-made disturbances. For example, the Covid-19 pandemic created severe global economic crisis, which caused either recession or a depression in a number of countries. Since there are no specific ways to predict such disturbances, supply chain resilience can create market superiority and opportunity to benefit from the existing disturbances [1].

Nowadays, resilience is considered as one of the critical factors in supply chain management. Understanding resilience and investing that creates a market advantage for the company and allows the supply chain to adjust itself to disturbances and recover quickly.

One of the common environmental threats to the supply chain is economic depression which can disturb or even collapse the supply chain when demand and cash flow decrease. In the covid-19 pandemic number of countries experiencing an economic depression and Iranian market has

been suffering from depression for some time. Since Iran has an edge on the carpet industry, sustaining and expanding a resilient and efficient supply chain for this industry has an important role in job creation, importing the currency, and supporting many related industries to create a high turnover in the market.

Thus, due to the increased importance of the supply chains in the current economic situation of Iran and the role of carpet industry as one of the leading industries with an extended supply chain, it is necessary to identify strategies affecting the supply chains of this industry, so they can continue to compete in the international market during the economic depression. This research intends to study, identify and analyze the strategies affecting the resilience of the supply chain of the machine-made rugs industry during the economic depression. Considering the nature of supply chains and the need to cover all the concepts involved in data gathering and analysis processes, special attention has been given to all three functions – specifically: sourcing, production, distribution – and the study has been organized based on them.

II. THEORETICAL FOUNDATIONS

A. Supply Chain

Reference [2] defines supply chain as the activities pertaining to the moving material from their raw state to their final form at the end customers' hand, including resources and support, production management, order processing, stock management, transportation, storage, and customer service.

Reference [3] defines a supply chain as a network of institutions working to create value for end customers through products and services by connecting with the upstream and downstream in their different processes and activities.

Extreme international competition in the 1980s leads international organizations to produce low-cost, high-quality, reliable products with more flexibility in their design. In this era, with the strategic collaboration of suppliers and manufacturers, the concept of supply chain management appeared. Supply chain management is defined as an all-encompassing philosophy to manage the overall flow in the distribution channels from the suppliers to the end customer [4].

With companies becoming more specialized, national and international competitions are rising, and the decisions made in each point of the supply chain affecting the rest of the chain, supply chain management has become ever so important. For proper management of a supply chain,

appropriate decision making on planning, strategy, operations and tactics are necessary [5].

Planning in this section includes identifying organizational goals and implementing the strategies for achieving the goals and activities for collaboration and system integration. All these factors help us to achieve a proper supply chain strategy. After planning, the supply chain has to be designed for production of a specific product or service. Senior executives are responsible for decision making about the mission and the organization's policies, designing appropriate supply chain for customer demands, easing product development, production, support, and resilience of the supply chain. It is the operations factor that uses a transitional process and creates the value added by converting the input to output [5].

Strategic supply chain management is essential and necessary for achieving the main goal, which is probably customer satisfaction. For achieving this goal, organizations out to acquire the required skills and competencies for choosing a trustworthy supplier, creating added value for their products and services through the supply chain so that they can enjoy the benefits of profit-making and competitiveness [5].

Tactical supply chain management is necessary for handling the changes in the supply chain. It includes overseeing the supply chain constantly using proper software for sharing information and constant planning for making the required changes in the supply chain [5].

B. Supply Chain Resilience

The first brief definition of supply chain resilience can be seen in a paper by [6] at Cranfield University after research on creating a resilient supply chain. They define resilience as a system's ability to return to its original state or move towards a better state after the introduction of chaos.

The concept of resilience is multi-dimensional and multi-disciplinary. Resilience has been studied in environmental, social, psychological, economic, organizational, supply chain risk management, and supply chain studies.

In environmental perspective, resilience is defined as the amount of disturbance a system can tolerate. This is considered one of the traits of human beings that they can learn and adapt to unpredictable events in their environment. Since this perspective provides a comprehensive image of the life processes, environmental concepts are usually used in conjunction with the concept of resilience in social sciences [7].

The psychological perspective of resilience has its roots in a theory that studies people's behavior during their lifetime. Reference [8] have defined resilience as psychological pathology of growth, examining the differences in growth as an individual's response to stress and adversity. Related studies look at factors that hinder or balance the proportion of side reactions to stress.

From the organizational perspective, resilience has been defined as the ability to adjust the capacity or capabilities. Another important aspect is discussed in the organizational perspective is the results of resilience. Reference [9]

emphasize that organization's sensitivity to the environment and looking for strategic choices and reorganizing supplies are essential for organizational resilience. These factors will provide them a competitive advantage in times of crisis. With focusing on resilience as organizational ability, [10] believes that resilience is key for developing a sustainable strategic plan and that a resilient organization can perform better in times of chaos and uncertainty than less resilient competitors.

Reference [8] points that resilience can be applied to microeconomics [individual level], middle-economics [market level], and macroeconomics [national level]. These levels reflect the society's outlook and can run at the company level or the supply chain.

Reference [11] mentions the possible disturbances from unexpected natural causes or human disasters and that supply chains are becoming more complex. He emphasizes that the supply chains should take new strategies to improve their ability to have a fast and low-cost response to unpredictable changes.

There has been number of research on identifying a set of metrics for assessment of supply chain resilience. A recent research defined a new set of measurements by integrating different existing resilience metrics consist of recovery level, lost performance during the recovery period, and Time-To-Recovery. It is shown that choosing these resilience metrics influence on the selection of risk management strategies in a modeling supply chain [12].

Reference [13] identified that supply chain resiliency could influence sustaining reputation throughout the improvement of business attractiveness, financial performance, reliability, and service quality. They also find out that reactive resilience couldn't lead to reputation always.

The goal of supply chain resilience is to recover the disturbed system to a desirable state in a reasonable time and cost. A resilient supply chain has to be able to control known effects and predictable and preventable dangers by running operational calculations, also be able to resist the potential dangers that are not preventable. Additionally, in the short term, it should be able to reduce dangers leading to catastrophes in factories or distribution centers and start normal operations again [14].

Researchers also studied the relationship between supply chain resiliency and its impact on risk management, market, and financial performance. They concluded that supply chain resilience was related to financial performance in a disruption time and related to a supply-side disruption occurs. Also, they represented that supply chain resiliency improves risk management and market performance in cope with a high level of infrastructure disruption. And increasing supply chain resiliency in a time of catastrophic disorders could cause higher-level risk management and market performance. As a result, they showed that developing supply chain resiliency has positive effects on risk management, market performance, and financial performance, and its associated costs are worth it [15]. The decision on outsourcing against in house production can play an important role in economy depression time. Outsourcing is a strategic decision

based on outside agreements for doing nonstrategic activities aligns with producing a product or offering a service, made with organizations capable of doing those activities to improve competitive advantage [16].

The literature review identified contribution of number of key factors in supply chain management and their impact on financial performance. This research has categorized the factors into three different themes as below:

TABLE I
SUPPLY CHAIN THEMES AND KEY FACTORS

Themes	Key Factors
Sourcing	Supplier selection: Local/National/Global Suppliers, Single/multi supplier, Logistics, supplier/buyer relationship, supply contract, in house/out sourcing
Production	Production Layout, Production process, outsourcing, in house, Inventory control, capacity, batch size, packaging, product variety
Distribution	Logistics, outsourcing, Centralized/Decentralized, market expansion

C. Economic Depression

In the related research literature, this concept has been introduced using two expressions of depressions and recession. A lot of researchers consider depression as a series of severe recessions during which Gross National Product [GNP] falls more than 10 percent [17].

Reference [18] counts customer's inclination to spend less, increased unemployment, decrease in credits, and increase in competition over reducing prices as characteristics of depression times. They mention that in times of economic depression, profit margins decrease, and along with price cuts, competition increases, and with the decrease of profit margins, efficiency drops. That is why international competition intensifies during the global economic depression. Also, during the economic depression, banks endow fewer loans and inadvertently put businesses under tension, causing a drop in the number of active businesses. In the short term, depression causes drop in sales, profit margin, and credit, introducing a shock to the resources available to a company and thus threatening its sustainability. In times of economic depression, the volume of the gross domestic product coupled with the volume of sales and consumption decreases. In order to guarantee a minimum fixed volume of sales, manufacturers reduce costs or produce new products [19].

As we have experienced multiple economic depressions, studies have also been done on this domestically. Reference [20] have found that economic booms have happened during times when oil price and consequently, oil revenues have experienced their maximum. Concluding that, the price of oil plays a significant role in creating economic depression or boom in Iran.

D. Experimental Foundations

Reference [21] considered resilience and sustainability in a closed-loop supply chain simultaneously and investigated the effects of supply chain strategies on resilience. Information sharing and multiple sourcing were chosen for making supply

chain resilient. The results showed that integrating resilience and sustainability in the closed-loop supply chain is necessary to meet customer needs. The research identifies that as the expectancy of disruption increases in high market demand, there is a greater need for backup and multiple sourcing strategies.

In a study, the relationship between supply chain dynamism, Supply Chain Disruption Orientations [SCDO], Supply Chain Resilience [SCR], and financial performance is investigated by a developed conceptual framework tested empirically by using survey data from 241 Chinese manufacturing industry and structural equation modeling. This research reveals that accordance between supply chain dynamism and SCDO and SCR is essential. It is also shown that SCDO influences improving SCR, which has great direct effects on financial performance [22].

On different research [23] investigated the impacts of communication and cooperation on SC resilience and assessing these subsequent impacts of resilience on supply chain performance. They proved that the quality and history of relationships have positive direct and indirect effects on supply chain resilience, affecting supply chain performance.

A study on resilient strategies for the agribusiness supply chain has investigated the impacts of both robust and resilient strategies in harvest time disruptions. They developed a programming model which maximizes profit by choosing optimal strategies. The results proved that a combination of robust and resilient strategies have most effective for mitigating supply side of agribusiness supply chains. They stated that supply chain resilience strategies are becoming more important as perishability increases [24].

Meanwhile, [25] designed resilient supply chains using a mixed integer non-linear model to find mitigation policies in different situations of disturbance. These strategies include keeping emergency stock at the retailers, reserving backup capacity at the suppliers, and multiple sourcing.

One of the articles about supply chain resilience is obtaining different mitigation strategies and a resilient procurement policy. In this study, strategic and tactical procurement planning in a supply chain network are developed [26].

Reference [27] introduced three resilience strategies that have a considerable impact on supply chain. They are including facility dispersion, facility reinforcement, and multiple sourcing.

Reference [28] applied a model for designing and planning in five supply chains for different disturbances that implemented demand uncertainty. In this study, disturbances were modeled in a probabilistic method. They had eleven indicators for assessing supply chain resilience, including network design, concentrations, and operational indicators. The aim of this study was to provide managers with expected operational effects to evaluate network behavior, the concentration of indicators, and resilience behaviors known in the literature. It also aimed to recognize the main traits that managers should consider in planning and designing a resilient supply chain.

Reference [29] studied the effect of collaborations on the resilience of supply chains. They studied the relationships between eight buyers and suppliers in the food industry. They concluded that collaborative behavior [sharing information, a relation based on cooperation, developed shared knowledge, an effort for a reciprocal relation] increases the resilience of a supply chain by its effect on observation, speed, and adaptability.

Reference [30] have studied the role that procurement plays in identifying and managing inter-organizational and intra-organizational issues affecting the resilience of supply chain. This study identified the inter-organizational and intra-organizational enablers and barriers that impact the supply chain through procurement. Using the resulting concepts, they have pictured a framework for the relation between inter-organizational and intra-organizational issues with the supply chain resilience from the procurements point of view. They concluded that with good management and control of inter-organizational and intra-organizational issues by procurement managers, a high-level resilience could be achieved in the supply chain.

In another paper, a model for resilience against risk and preventing probable risks has been made based on decision making criteria for planning and controlling the internal business factors. This model manages the supply chain by identifying, planning, and controlling internal business factors that make the supply chain resilient against different types of risk [14].

In an article, by analyzing the supply chain and the related dangers, [5] have studied its resilience and introduced appropriate strategies and necessary tools for countering those dangers. At the end, they have concluded that an organization can go back to the pre-change state in the supply chain by using the four strategies of lean production, Six-Sigma, flexibility, and strong organizational culture.

In another research to redesign the supply chain for resilience by simulating Portugal's auto industry, it was concluded that a supply chain's behavior after a disturbance could be studied using two effective strategies in reducing the impact of disturbance. It was found that when flexibility strategy is used, the total cost will be lower and when the redundancy strategy is used, delivery times improve [31].

Reference [32] introduced a conceptual framework for supply chain resilience that shows balanced resilience is achieved by a balance between vulnerable and strong points.

A study has been done in the Arvand Industrial Group in 1395 for identifying and prioritizing suppliers' resilience assessment indexes using the best-worst multi-criteria decision-making method. Results show that agility, redundancy, and observability are, in order, the most important indexes for evaluating supply chain resilience of Arvand suppliers [33].

In another research, [34] in addition to studying the concept of supply chain resilience, have studied the risks and disturbances of supply chains, proceedings, enablers, and supply chain resilience indexes. They provide a framework for

optimizing a resilient supply chain by studying the relation between resilient proceedings and the operation of the supply chain, considering the previous studies and the present evidence.

Reference [35] have studied the model of inter-organizational collaborations for optimizing the performance of the machine-made rugs' supply chain using the two theories of social exchange and transaction-cost. Their main finding is utilizing the side communication factors in supply chain and creating a collaborative inter-organizational relation for optimizing the performance of the Iranian machine-made rug industry.

Reference [36] have studied supply chain stimulants in their paper and have categorized and examined their relation to the Iranian machine-made rug industry's supply chain. They have categorized eighteen stimulants in four categories: proceeding of supply chain, customer and product, competition, and communication. They state that among supply chain stimulants, supply chain proceedings were more related. They indicate that among the performance evaluation factors, supply chain proceedings have more impact on the supply chain's performance than other factors and the impact of other factors is roughly the same.

Most of the studies done on supply chain resilience are on definition, design, and its principles. Few of them are on how to implement these principles and measure resilience. Also, there hasn't been a study on the resilience of a supply chain against a specific disturbance. Since economic depression is a disturbance to the proper performance of supply chains and they need resilience against it to perform well, in this study, we have focused on strategies affecting the resilience of supply chains in times of economic depression.

III. RESEARCH METHODOLOGY

In this study, Researcher has taken two approaches; First, using induction method to identify a collection of theories, including strategies for supply chain resilience in times of depression by carefully studying seven factories and using Thematic analysis of their operation change in different indexes. Second, the resulting theories from the case studies analysis have been evaluated by experts inductively and the approved strategies have been presented as the results of this study. Table II shows the summary of our research methodology.

The first phase of this research was the study of theoretical literature and research background which has been done through library study and note-taking. All published studies with supply chain resilience, rug industry's supply chain, economic depression, and strategies for sourcing, production, and distribution in supply chain, have been considered as source of investigation. The resources were narrow down by criterion based on the most recent, more relevant and accessible papers.

Next phase was field work, and data from machine-made rug industry has been collected. Data has been collected by

TABLE II
RESEARCH PHASE

Methodology	Tools	Studied Sample	Population	Research Phase
Library research	Note-taking	Criterion based on novelty, accessibility, close relationship with the topic	Relevant and recent publications and text books	Literature Review
Scaling	Semi-structured interviews and Observations	9 Major machine made rugs selected by Criterion based on indexes like Establishment history, Working on the industrial scale; Accessibility of the data and Growing or maintaining the performance level during a depression	All major large size machine-made rug manufacturer in the country	Field work, data collection
Statistical scaling and analysis	Questionnaire, SPSS software	18 experts in relevant field and industry	Industry and University experts	Data analysis and validation

semi-structured interviews. The target population was all large machine-made rug producers in Iran. Sampling has been based on criteria such as time of establishment, working on an industrial scale, accessibility of information, keeping or growing the performance level during the depression. We detected nine companies that met these criteria. And we could have an interview with seven of them. Considering the samples used in this study are these machine-made rug factories: Mashhad Carpet, Mashhad Negin Carpet, Kashan Khatereh Carpet, Setareh Kavir Carpet, Tandis Carpet, Baharestan Carpet, Jamal Industries Carpet and Zomorod Carpet.

Among the sample producers two had similar characteristics such as time of establishment, management team, mission and vision, only one of them was selected for contribution to this research.

A. Mashhad Carpet

Mashad Carpet is the oldest rug factory in Iran and one of the eight factories of Mashhad holding. It started its operation in 1977 and is one of the country's most modern machine-made rugs production centers. This company has 15 weaving carpet machines with 800 employees. The market share of Mashhad carpet is almost 8% in Iran and exports 80000 sqm rug to more than 30 countries in the world.

As for operation changes in Mashhad Carpet's supplying efforts, it should be noted that before depression, all the required thread was supplied within the company. But in depression times, executives of Mashhad Carpet, who were after reducing costs, decided to form another company to get their threads for first samples of new products. Since each cauldron of dye needs a large volume of thread and production of this volume of dyed thread for two sample carpets, they are unsure whether its sales are economical.

There is categorization of their products based on the size of the order or demand. Meanwhile, in the depression era, satisfying all customers becomes more important, including those looking for small purchasing such as children-room carpets and fantasy carpets. Thus, Mashhad Carpet decided to

outsource its small production of children-room carpets and fantasy carpets. Also, Mashhad Carpet business strategy has been on cash transactions rather than giving credit to customers or suppliers. However, due to depression, they decided to reduce contracts duration with their suppliers to have more cash flow and avoid the risks of an unstable trading market.

Operation Changes in supply chain production part have happened in four areas. First, to balance the supply and demand they reduced maximum inventory level. As a result of reduction in demand and inventory, Mashhad Carpet managed to change its production to make-to-order and have more accurate forecasting. However, prior to depression time the strategy was based on continuous production with maximum capacity.

Second, in the case of investment in production, the company faces changes in human resources. They have stopped employing new personnel and did not even replenish its retired employees.

Third, depression causes the customers to become more interested on mass customization and be more diligent in their purchases, so Mashhad Carpet has increased its product variety to cover more customer tastes and increased its flexibility in composition. Also they decided to reduce weaving new orders and increasing its flexibility in production volume.

Changes in distribution are first related to the changes in the expansion of the domestic market. During the depression, customers became more price-sensitive and Mashhad Carpet's put effort to increase product variety.

On the other hand, Mashhad carpet management decided to eliminate the non-added value steps by removing middle men and have direct sales of their products to the end customers. Their goal is to make %85 of their sales directly to end customers.

Another change in their supply chain's distribution section is their inventory level. During the depression, the goal would be to minimize the stock level of their products.

B.Negin Mashhad Carpet

Negin Mashhad Carpet was established in 1992 in Mashhad. It produces machine-made rugs with classical and modern patterns. Negin has 13 weaving carpet machines with 527 employees. This company is one of the biggest and up-to-date spinning factories in Iran with 6% of total market share in Iran.

Supply operation changes at Negin have been in contract lengths and volume of raw material purchase. During the depression period, decision making and contract lengths have decreased. Also, no definite purchasing orders are presented to the German supplier as there is a high likelihood of changes in the number of orders. The average purchase volume of raw materials has also decreased due to depression.

Regarding production changes at Negin, this company has stated that the most prominent effect of depression is a decrease in production volume, which is damaging to large scale factories, causing energy efficiency, manpower, and investments to decrease. Additionally, the system used to operate in a more confident manner and its decisions were for more extended periods. In the current situation, the decisions need to be refined in short periods and a lot of changes happen in the whole system. In general, activities have increased and trade-ins have decreased. Due to decline in sales and customer orders, production category sizes have decreased compared to the booming period.

Before the depression, production was solely based on Market forecasts, but during the depression, production is more based on orders and less on market forecasts. Regarding production investment, it should be noted that machines that gave a lesser profit margin have been sold off to create cash for purchasing new machines, while if it was not due to depression, the company would not have sold any of its machines. In regards to investment in human resources, it should be noted that this company has not replenished its retired forces. There has been flexibility in accepting orders of carpets in sizes, patterns, and colors due to the increase in product variety to attract more customers during the depression times.

In regards to the distribution part of the supply chain, to gain more market share during the depression, Negin has increased its product variety and decreased production time seeking to expand its domestic market. Negin has also increased the variety in thread count of its products based on demand. It has also rationalized the amount of production and reduced its stockpile to keep its cash levels.

C.Khatereh Kashan

Khatereh Kashan Spinning and Weaving Company started its operations in 2005 in Kashan. It is among the well-known producers of machine-made rugs in the country. It has 11 weaving carpet machines and 430 employees. The company holds 6% market share in Iran approximately. Designing is an essential process in any machine-made rug producing. Khatereh Kashan has one of the greatest teams in this field.

There have been many operational changes in its sourcing of the supply chain. Appropriate measures have been put in

place for outsourcing international orders during the depression. In the past, all international orders were fulfilled within the company but lately, since the production capacity is reduced, international orders, which have a strict delivery timeframe, are outsourced to trusted producers in case they cannot fulfill the order in time due to their reduced production capacity.

Other operational changes in sourcing at Khatereh are related to the suppliers. Before the depression, the company used to purchase some of its raw materials from third-hand middlemen, but now they are all removed due to the high costs they impose on the system.

There have been operational changes in foreign purchases also, no more direct purchases from foreign suppliers are made and all of them are done through middlemen but under Khatereh's terms. As for the number of suppliers, the number of domestic suppliers has decreased due to the change in the contract conditions. As for the contracts' length, before the depression they were for six months and payments were made in installments. After the depression affected the company's sales and cash levels, the contract length increased to 8 months. Additionally, there have been changes in purchase volume; procurement of raw material from foreign suppliers has halved in volume and number of purchases. This decline in foreign purchases has been covered by domestic suppliers.

Changes in the production part of the supply chain of the Khatereh have been in different areas. Before the depression, production was based on the opinion of the sales unit or in other words, sales forecast, and they always kept a certain amount of products in their warehouse, but during the depression, with the increase in the finished product's price and the elevated attention given to costs management, production is done by order. Respectively the size of product categories has decreased. Khatereh's investment planning has always leaned toward renovation and expansion, but due to depression this has become harder to execute and slower to advance. As for manpower, Khatereh has not done any new hires or layoffs. Due to the challenging economic conditions of the depression era and delays in paying wages, some workers have left the company. In terms of flexibility in composition and volume, Khatereh's main focus in production is on patterns and colors. This aspect has become pronounced in recent years and Khatereh has increased the variety of colors and patterns in its products. It has also flexed in accepting orders for products of different sizes. Changes in the distribution of Khatereh for expansion in the domestic market have been done by increasing the variety of colors and patterns and thread count of the produced carpets. Before the depression this company did not have retail sales, but during the depression it has started an effort to make direct sales. As for its stockpile, the goal is to keep it at zero. The change made in the distribution channel is the introduction of direct online sales to end customers. With the increased value of customers during the depression, Khatereh has created an internet sales website to make the purchase process easier and more convenient.

D.Kashan Tandis

Kashan Tandis Textile Company was established in 2005. Tandis was one of Khater's holding members, but it is separated now and is independent entirely. This company has ten weaving carpet machines and 373 staffs and workers. The market share of Tandis is almost 4% and it has a new management team who is very risk taker that can make different and risky decisions.

The most important change made in Tandis due to depression has been the change in its management and utilization of managers capable of steering the company to success in these difficult conditions. The new managers put the unused machinery into use and assembled the unassembled spinning machinery to reduce costs by utilizing unused production capacity; thus, the company produces all its required threads internally, contrary to its previous practice. Another change has been in contract length, which has increased to assure Tandis' ability to pay.

In the production part of the supply chain previously, Tandis used market elasticity, sales average, market demand, and fixed customers' orders to determine its production volume and some inventory was kept in the warehouse. In other words, production volume was both based on orders and forecasts, but with an increase in their customer number during the depression, nowadays, most of their production is based on orders and with maximum capacity.

About the production site, after the change in management and increase in production potential for three kinds of carpets [Acrylic, rug, cape knitting], all machines are now concentrated in a central site. As for flexibility in compound, they have increased it by increasing the variety in their carpets' patterns. Activation of their rug and cape knitting division has also contributed to their flexibility in composition. As for flexibility in production volume, activation of their spinning division has enabled them to accept orders for new colors and sizes of carpets.

There have been changes in the distribution part of the supply chain of Tandis, mainly their share in the domestic market. The company's domestic market share has increased due to a significant increase in their orders, sales and their focus on the domestic market in addition to their increase of product variety, adding knitting capes and rugs to their product category. As for centralization or decentralization of distribution and stockpiling, Tandis used to make all of its sales in its central office in Tehran but currently with their shift in sales strategy to focus their energy and time on marketing, sales and gaining more customers and thus more production, usage of Tehran's office and warehouse have switched from wholesale to retail. As for inventory, since all Tandis' production is order based, the time of product storage is until the order's fulfillment, while previously, this company used to store some of its inventory in their warehouse.

E.Setareh Kavir Yazd

Setareh Kavir Yazd Carpet Company is the first company in the Setareh Kavir Yazd Industrial Group consist of seven different factories. It was established in 1981. Setareh Kavir is

the biggest machine-made rug factory in Iran and it is located in Yazd province. It has 18 weaving carpet machines and 915 staffs and workers. Setareh has 9% of the market share in Iran and exports nearly 200000 sqm rug to the other countries on five continents.

Changes in sourcing of the Setareh Kavir company are in the contract length, purchasing the raw material from domestic or foreign suppliers and the number of purchases. The contract length has increased due to reduced sales to manage the lowered cash flow. Before the depression, Setareh Kavir bought most of its required raw material from foreign suppliers, but with the occurrence of depression, a lot of obstacles have been introduced on the way of this practice. To avoid these obstacles, Setareh Kavir nowadays makes most of its purchases from domestic suppliers. As for the number of purchases, it is said that both the number of purchase and the volume of each purchase from domestic suppliers has increased in times of depression.

The reported operation changes in the production section of Setareh's supply chain are that the existing depression in the market and its impact on the initial production point has caused the product categories to shrink. Regarding investment, with depression, the sale process of some machinery has slowed and the company has been lagging behind its plans. Setareh has increased its flexibility in its product variety by introducing variety in its patterns and carpet collections. Flexibility in production volume has decreased in the production starting point for producing new patterns or orders.

In the distribution section of its supply chain, due to depression, only two changes have happened. To achieve its goal of domestic market expansion, it has increased its product and collections variety to cover more tastes of its customers and thus increased sales. Setareh produces carpets with different thread counts and this variety in qualities also causes market expansion. About the other changes in the distribution system, it should also be noted that Setareh's is the only company among seven studied in this paper that uses distribution centers all around the country and has expanded its distribution centers during the depression to reduce distribution and warehouse costs.

F.Baharestan Bidgol

Baharestan Bidgol Textile Company was established in 2004 in Aaraan & Bidgol, the hub of Iran's machine-made rugs. This company was recognized as the exemplary production unit of the Isfahan province in 2011. Gradually this company started producing different kinds of rugs and carpets and fantasy models. It has nine weaving carpet machines and 304 staffs and workers with 2% of the rug market shares in Iran.

In sourcing, this company has tried to make contracts with longer grace periods but finding suppliers that agree to their terms has been difficult since due to depression, their sales have dropped and their production and consequently their purchase volume of raw material. As a result, needing more time to pay the suppliers has caused them to lengthen their contracts. Due to depression, sales management has become more important. Before the depression, purchases were made

in high volume and warehouse stockpile was not a concerning matter. During the depression, more attention has been given to purchase management and production has reduced causing the raw material orders to lessen in number and volume.

Before the depression, production was based on orders at Baharestan, and the orders were enough to max out the production capacity, but this is not the case during the depression; thus production is done both based on orders and forecast. With a reduction in sales and Baharestan's effort to increase production and sales, product category sizes for new carpet patterns have decreased. Like all companies studied in this paper, Baharestan has always maintained its program to renovate its machinery. As for the effects of depression on investments in machinery and human resources, to reduce their production cost, Baharestan has completed its internal finishing line and thus employed more people and opened a second production site. Baharestan has also increased its product variety to increase its sales causing more flexibility in composition. During the depression, Baharestan has generally suffered from a decrease in the number of incoming orders, so it has lowered its standards for accepting orders in colors, patterns, and sizes to maintain its production volume and sales high amount.

In the distribution part of its supply chain, to increase its domestic market share, Baharestan has increased its product variety, including introducing rugs to its product category. As for changes in sales and centralization in distribution, before the depression all sales from the factory were wholesale, but during the depression a factory outlet has opened. Also, in distribution, since production is based on both orders and forecast, warehouse stockpile has increased.

G. Jamal Industries

Jamal Industries Company was established in 2003 in Kashan. It is one of the few machine-made rug companies that have targeted foreign countries and exports whole productions to other countries such as Afghanistan, Pakistan, and Iraq. Jamal has nine weaving carpet machines and 195 employees.

Jamal Industries Carpet: Operational changes in sourcing practices of this company are reducing the number of suppliers due to the depression and the change in terms of material supply. Purchase volume from foreign suppliers has also decreased and has been substituted with domestic suppliers. There are no more direct purchases from foreign suppliers and all foreign purchases are done through middlemen. Purchases from domestic suppliers are done both directly and through middlemen, the change made in the depression era is that all third-hand middlemen are eliminated. Contract lengths have increased due to depression in the market and low cash flow. There has been a strategic change in Jamal Industries due to depression, which is related to a change in the destination market that has also affected operational decisions about production. Before the depression, production was based on both orders and forecasts and sales were made both domestically and internationally. After the depression, due to the difficulty of competition in the domestic market, Jamal

switched to the only target the international market and all of its products are geared towards export. Thus, all production is done by foreign orders. Jamal has also been forced to upgrade its technology and increase its machinery to meet its foreign customers' demands, leading to increased employment. Due to this expansion and limited available space in its original site, production is currently done in three different sites. Jamal adjusts its production to its foreign orders and since they are usually low in volume, in general, the size of production categories has decreased. On the other hand, since Jamal only produces its products for export and foreign customers have a limited taste for color and patterns, its production flexibility is lower than other companies in this study. Despite this, Jamal tries to meet the variety of tastes existing in its different destination countries and has set its production system to produce a variety of carpets. As for flexibility in accepting orders with different volumes, since orders are limited in colors, patterns, and sizes, flexibility has increased. As for the distribution part of the supply chain, as mentioned before depression, Jamal distributed its carpets both domestically and internationally and was working on its expansion, but since it was not able to compete domestically, it focused solely on the international market after the depression and was able to expand its market share internationally. With this change of strategy, all carpets are produced based on order and warehouse stockpile has decreased. As for centralization in distribution, Jamal used to have both wholesale and retail at its factory but currently guarantees transportation of its product up to the border point and delivers the orders to its customers at the country's border.

The table below summarizes the number of staff, machines, and the market share of case studies.

Before finalizing the questions a pilot study was carried out to validate and test the variables and their impact on the outcome. A set of questions were designed and distribute to a number of experts within field and industry and a total of 18 experts from University and industry answered the questionnaire.

TABLE III
COMPARISON OF COMPANIES

Name of Company	Number of Wiving Carpet Machines	Number of Staffs	Market Share Percentage [approximately]
Mashhad Carpet	15	800	8%
Negin Mashad Carpet	13	527	6%
Khatereh Kashan Spinning and Weaving Company	11	430	6%
Kashan Tandis Textile Company	10	373	4%
Setareh Kavir Yazd Carpet Compa	18	915	9%
Baharestan Bidgol Textile Company	9	304	2%
Jamal Industries Company	9	195	-

IV. RESULTS

This study has been done to find the strategies affecting the resilience of supply chains during times of economic depression. Information gathered from interviewing seven producers of machine-made rugs [Mashhad, Negin Mashhad,

Khatereh Kashan, Tandis, Setareh Kavir Yazd, Baharestan, and Jamal] during two depression eras and before that, is summarized based on three stages of sourcing, production, and distribution. The three tables below are summarizing the findings of the research.

TABLE IV
SUPPLY CHAIN SOURCING PHASE CHANGES IN DECISIONS

Decisions	Mashhad Carpet	Negin Mashhad	Khatere Kashan	Sanaye Jamal	Satare Kavir Yazd	Tandis	Baharestan	Detected THEME
Make or Buy Raw Material?	Supplying threads for knitting the samples from outside the company	No change	No change	No change	No change	Establishing a spinning production line	No change	-
Outsourcing Finished products?	Out sourcing of fantasy rugs	No change	Out sourcing of some foreign orders	No change	No change	No change	No change	Out sourcing
number of suppliers	No change	No change	Reduction in number of domestic suppliers	Reduction in number of domestic suppliers	No change	No change	Reduction in number of suppliers	-
Supply chain structure	No change	No change	Removing direct connection with foreign suppliers Removing the third-grade middlemen from domestic SC	Removing direct connection with foreign suppliers Removing the third-grade middlemen from domestic SC	No change	No change	Direct Connection with domestic suppliers	Reduction in number of the middlemen
Suppliers contract length	Reduction	Reduction	Increasing	Increasing	Increasing	Increasing	Increasing	-
Purchasing from domestic or foreign suppliers	No change	No change	No change	No change	Replacing foreign suppliers with domestic suppliers	No change	No change	-
Purchase volume from suppliers [size of purchase categories]	Reduction	Reduction	Reduction	Reduction	Increasing	Increasing	Reduction	-
Collaboration and cooperation with other producers in supplying raw material or products	No collaboration or cooperation	No collaboration or cooperation	No collaboration or cooperation	No collaboration or cooperation	No collaboration or cooperation	No collaboration or cooperation	No collaboration or cooperation	No collaboration

TABLE V
SUPPLY CHAIN PRODUCTION PHASE CHANGES IN DECISIONS

Decisions	Mashhad Carpet	Negin Mashhad	Khatere Kashan	Sanaye Jamal	Satare Kavir Yazd	Tandis	Baharestan	Detected THEME
Mass production based on forecasts or orders	forecast and orders	forecast and orders	orders	foreign orders	forecast	orders	forecast and orders	-
Size of production categories	Reduction	Reduction	Reduction	Reduction	Reduction	Reduction	Reduction	Flexibility in volume of products

Investment in production capacity [i.e. human resources, machinery, etc.]	Planning for technological upgrades Not replacing retired employees	Selling machinery with a low profit margin Not replacing retired employees	Lag in plan execution Reduction in manpower	No evidence has been observed showing any change	Lag in plan execution	Establishment of spinning	Establishment of sizing and shearing line	-
Ratio of human factors to technology	No change	No change	No change	No change	No change	No change	No change	-
Centralized or decentralized production	No change	No change	No change	Increasing number of sites	No change	Reduction in number of sites	Increasing number of sites	-
Collaboration and cooperation with other producers	Lack of collaboration	Lack of collaboration	Lack of collaboration	Lack of collaboration	Lack of collaboration	Lack of collaboration	Lack of collaboration	No collaboration
flexibility in the composition of products	Increase in product variety	Increase in product variety	Increase in product variety	Increase in product Variety	Increase in product variety	Increase in product variety and innovation	Increase in product variety	Expansion and completion of the product category Flexibility in composition
flexibility in the volume of production	Adjustment of order taking standards	Adjustment of order taking standards	Reduction of the production start point	Increased flexibility in the amount of foreign orders for production	Reduction of the production start point	Increased flexibility in the amount of new production	Reduction of the production start point	Flexibility in the volume of products

TABLE VI
SUPPLY CHAIN DISTRIBUTION PHASE CHANGES IN DECISIONS

Decisions	Mashhad Carpet	Negin Mashhad	Khatere Kashan	Sanaye Jamal	Satare Kavir Yazd	Tandis	Baharestan	Detected Theme
Extending or limiting target markets, [domestic or foreign]	Expansion of the domestic product variety	Expansion of the domestic product variety	Expansion of the domestic product variety	Stopping domestic product market	Expansion of the domestic product variety	Expansion of the domestic product variety	Expansion of the domestic product variety	Expansion of market to price sensitive groups
	No change in foreign market	No change in foreign market	No change in foreign market	Expansion of foreign market	No change in foreign market	Expansion of foreign market	No change in foreign market	Change of direction to foreign markets
Centralized or decentralized warehouse and distribution	Reduction in inventory	Reduction in inventory	Reduction in inventory	Reduction in inventory	Reduction in inventory	Reduction in inventory	Increase in inventory	Direct sales and reducing middlemen
	No change in distribution	No change in distribution	Sales to end user	Delivery at frontier of Iran	Increase in distribution centers	Sales to end user at Tehran office	Sales to end user	
Number of warehouses and local distribution centers	No change	No change	No change	No change	Increasing the distribution centers to ten	No change	No change	-
Transportation Method	No change	No change	No change	No change	No change	No change	No change	-
Distribution channels and their variety [Retail stores, Distribution centers and ...]	No change	No change	sale via some stores Online sales	Only exportation	No change	Adding retail sale	adding retail sale	-
Ownership of	No change	No change	No change	No change	No	No	No change	-

distribution including the fleet					change	change		
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A strategy has been accounted in the hypothesis using the data from the table above and previous studies, when all or most studied companies have made a change in one of the operation indexes to counter the economic depression or some of the studied companies have made a specific change in their decision, but others have not. Also, the assumption of partnership and cooperation among the case studies' strategies has not been seen, and this assumption is derived from the research background. However, according to research findings, this strategy's effectiveness in the resilience of the supply chain in the machine-made rug industry has been studied. Accordingly, nine strategies have been identified that are more likely to benefit the resilience of machine-made rugs' supply chain. In Table VII, nine strategies have been brought.

The radar graph below gives an overview of the decisions made by the each of factories. It shows that how many producers have used which strategies to deal with the economic depression.

TABLE VII

Decision levels in supply chain	Strategies
Sourcing and Relationships management with Suppliers	Outsourcing the production of new products
	Outsourcing the production in new markets
	Reduction of middlemen and purchasing from the main supplier
Production	Expansion and completion of the product category
	Flexibility in composition and volume of products
	Collaboration and cooperation between domestic producers in operations and risk reduction
Sales and Distribution Network	Expansion of market to price-sensitive groups
	Expansion or change of direction to foreign markets
	Direct sales and reducing middlemen

RESEARCH VARIABLES

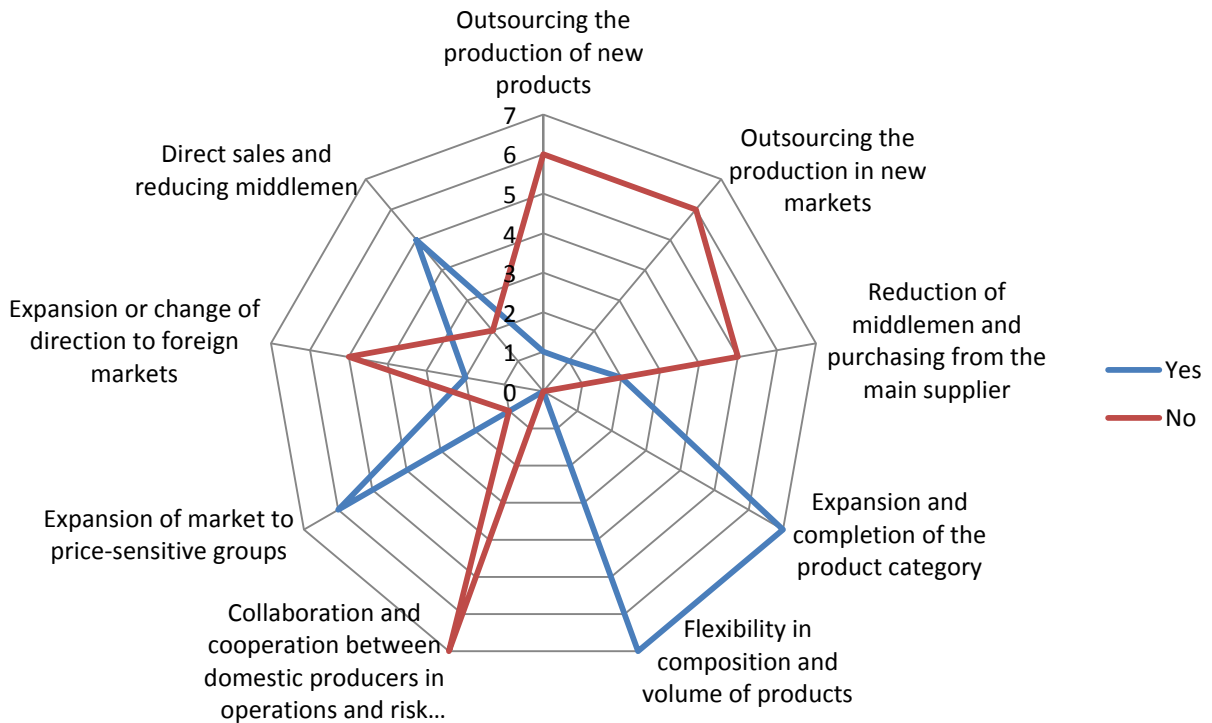


Fig 1. Results of Key Findings

A questionnaire consisting of nine questions was designed to confirm the results obtained from the interviews and sent to the 125 universities and industry experts, and 18 responses were received. To analyze the results of this phase, first Kolmogorov–Smirnov test was used to assure its normal

distribution. Since the distribution was found to be not normal, nonparametric sampling was used to confirm or reject the hypotheses. In the end, six of the nine variables from the

interviews got confirmed. Table VIII shows the summary of this statistical analysis.

TABLE VIII
STATISTICAL RESULTS

Variables	significance level	Confirm / reject
Outsourcing the production of new products	0.056	confirmed
Outsourcing the production in new markets	0.168	confirmed
Reduction of middlemen and purchasing from the main supplier	0.042	rejected
Expansion and completion of the product category	0.607	confirmed
Flexibility in composition and volume of products	0.115	confirmed
Expansion of market to price-sensitive groups	0.198	confirmed
Expansion or change of direction to foreign markets	0.030	rejected
Direct sales and reducing middlemen	0.286	confirmed
Collaboration and cooperation between domestic producers in operations and risk reduction	0.012	rejected

V. Conclusion and Suggestions

Supply chains have become more and more important in the industries and are under many unpredictable disturbances and complexities. That is why their resilience, recovering and growing from disturbances and stabilizing after crises, has become an important topic of study in recent decades. Research done in the field of supply chain resilience has been mostly in measuring resilience, presenting a framework for resilience and understanding the effective factors and supply indexes. For the first time in this research, we have studied strategies that affect supply chain resilience in the machine-made rugs industry during an economic depression.

As mentioned previously:

Sourcing strategies found in this study affecting supply chain resilience are:

1. Outsourcing the production of new products;
2. Outsourcing the production in new markets

In this study, some of the carpet producers, based on their needs, have used outsourcing to counter the effects of depression, like outsourcing the production of fantasy or unusual carpets or the production for foreign orders.

Outsourcing, being for new products or new markets, has been confirmed as an effective measure by the experts. It seems that this action has been done because it does not need constant capital and provides more flexibility for demand. Also, it is a way to meet the low volume and diverse orders of customers. Decision on outsourcing helped companies to drop the constant capital in facilities and have a lower break-even point with possibility of return of shareholders' equity.

This research identified production strategies affecting supply chain resilience as follow:

1. Expansion and completion of product category;
2. Flexibility in composition and volume of products.

Flexible production strategy affects an organization's ability to create a new product, changes in products, product composition, and designing products [37]. In this study, we observed that all seven companies reduced their minimum economically acceptable order size to increase their resilience in times of depression. They have increased varieties by adding other products such as rugs and started to produce carpets with more varied patterns and designs, adding to their product collection. These efforts were done to increase order numbers and cover the variety in customer taste and ultimately increase sales. The finding of this research is in agreement with [38] have stated that a strategy of flexibility makes companies capable of countering the uncertainty in the market.

The other findings of the research are on distribution strategies affecting supply chain:

1. Expansion of market to price-sensitive groups;
2. Direct sales and reducing middlemen.

During the depression, producers have increased their market share by introducing carpets with different qualities like carpets with densities of 300, 700, 1000, 1200, and mid-level prices. Also, they have increased their product varieties to cover different tastes and increase their target market.

In this phase the distribution system has changed from a decentralized form to centralized and direct delivery. Companies have turned to direct sales in response to lowered orders from wholesalers and generally tend to have a direct link to the end-user by establishing outlets. This will include some of the advantages of centralized distribution such as providing higher quality with lower cost.

In conclusion, with the economic depression in general and in machine-made rug industry in Iran as one of the country's leading competitive industries, these strategies can be used to improve this industry's performance and create resilience in its supply chain against depression. According to the results of this study, producers of machine-made rugs can implement changes in their supply chain to continue production and be profitable during times of economic depression. Additionally, by targeting a smaller portion or niche market and mass customizations like fantasy carpets and rugs, producers can increase their market share and satisfy the taste of various customers. This strategy creates opportunity to outsourcing the new products and focusing their capital and resources on their main strategic products such as fantasy machine-made rugs. During the depression, producers can complete their product categories and attract price-sensitive customers by introducing variation of quality level products. Finally, producers can continue their production and profitability while increasing their supply chain resilience in times of economic depression by utilizing this research's recommendations.

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